Ber. Inst. Erdwiss. K.-F.-Univ. Graz	ISSN 1608-8166	Band 9	Graz 2004

ROCK MAGNETIC INDICATORS FOR CLIMATE CHANGE

Robert SCHOLGER

Chair of Geophysics, Dep. of Applied Geology and Geophysics, Montanuniversität Leoben

Environmental magnetism includes the measurement and analysis of the magnetic properties of soils and sediments. Such measurements provide powerful tools for resolving key environmental problems, especially in climate and environmental change. In environmental magnetism, the presence of fine magnetic particles in many earth materials (e.g., marine and other sediments; soils; etc.) has been exploited to study the environmental processes that gave rise to the presence of the magnetic grains. A key attraction of environmental magnetism is the sensitivity of magnetic techniques in rapidly measuring minute quantities of magnetic particles in bulk samples (often equivalent to parts per billion in chemical analyses). This makes possible a large number of studies that simply cannot be addressed by other techniques without costly and time-consuming preparations that are often not representative of the material under investigation.

Concentration and grain size-dependent magnetic parameters can be powerful indicators of temporal variations in climatically-modulated fluxes of sediment in numerous environments, including the ocean floor and lake beds (Reynolds & King, 1995). Variations in pedogenic formation of *in situ* magnetic phases in interbedded loess/palaeosol sequences is also strongly controlled by climate. Such studies are providing important insights into the dynamics of palaeoclimate, including palaeomonsoon and palaeoprecipitation estimates, for significant portions of the globe. High-resolution archives of climate change are recorded in terrestrial (especially loess and palaeosol and lake sequences) and marine sediments. Periods of aridity are marked by increased dust fluxes from arid source areas. Periods of greater humidity are generally marked by reduced dust flux and increased weathering and soil formation. Magnetic analysis of natural sedimentary archives, enables identification of recent (including possible anthropogenic effects) and longer-term climate variability. Quantified reconstruction of climate changes can be gained from changes in sediment magnetic properties, once the causal links between climate and magnetic changes are established. For example, strong correlation between pedogenic magnetic susceptibility and rainfall has been shown by modern loessic soils in the N. hemisphere temperate zone (Maher & Thompson, 1995). These quantitative methods can be applied to other regions, such as North African loess/soil sequences in which major wet/dry cycles were identified through the Holocene (Dearing et al., 1996).

The reconstruction of the time schedule of the geological processes under investigation needs exact dating which can be performed only by well founded biostratigraphic data in connection with paleomagnetic and stable isotope data. In the Brunhes chron, several short reversal excursions were found and dated: the Laschamps (40-45 ka), Blake (110-120 ka), Jamaica (205-215 ka), Calabrian Ridge 1 (315-325 ka), Calabrian Ridge 2 (515-525 ka) and Emperor (560-570) occur globally and are well dated (Langereis et al., 1997). Other reversal excursions are not as certain, or occur so far only in restricted regions: Norwegian-Greenland Sea (70-80 ka), Albuquerque (155-165 ka), Fram Strait (255-265 ka), and the Levantine (360-370 ka).

In a new approach, magnetic parameters of rocks such as anhysteretic remanence and saturation remanence have recently been successfully applied to accurately date sediment sections independent from magnetic polarity zonation by means of correlation with astronomically driven climatic cycles (Dinares-Turell et al., 2002a,b). Analysis of Mediterranean marine cores indicated that they contain a detailed magnetic record of paleoclimatic and environmental variations.

Examples will be presented from sequences of glacial and interglacial sediments in Carinthia (Scholger, 2000) and from new sites in Upper Austria, which were studied for age determination and a reconstruction of the paleoclimate and depositional environment (Fig. 1). Paleomagnetic investigations included thermal and alternating field demagnetization of the natural remanent magnetization, measurements of magnetic susceptibility and anisotropy of susceptibility, and mineral magnetic studies such as magnetic saturation, S-factor and Curie-point determinations.

References

DEARING, J.A., LIVINGSTONE, I. and ZHOU, L. (1996): A late Quaternary magnetic record of Tunisian loess and its climatic significance.- Geophys Res. Lett., 23: 189-192.

DINARÈS-TURELL, J., SAGNOTTI, L. & ROBERTS, A.P. (2002a): Relative geomagnetic paleointensity from the Jaramillo subchron to the Matuyama/Brunhes boundary as recorded in a Mediterranean piston core, Earth and Planetary Science Letters, 194: 327-341.

DINARÈS-TURELL, J., HOOGAKKER, B.A.A., ROBERTS, A.P., ROHLING, E.J. & SAGNOTTI, L. (2002b): Quaternary climatic control of biogenic magnetite production and eolian dust input in cores from the Mediterranean Sea, Palaeogeography, Palaeoclimatology, Palaeoecology, 190: 195-209.

LANGEREIS, C.G., DEKKERS, M.J., DE LANGE, G.J., PATERNE, M. & VAN SANTVOORT, P.J.M. (1997): Magnetostratigraphy and astronomical calibration of the last 1.1 Myr from an eastern Mediterranean piston core and dating of short events in the Bruhes.- Geophys. J. Int., 129: 75-94.

MAHER, B.A. & THOMPSON, R. (1995): Paleo-rainfall reconstructions from pedogenic magnetic susceptibility variations in the Chinese loess and paleosols, Quat. Res., 44, 383-391, 1995.

REYNOLDS, R.L. & KING, J.W. (1995): Magnetic records of climate change, Rev. Geophys (suppl.), 33, 101-110, 1995.

SCHOLGER, R. (2000): Paläomagnetische Untersuchungen im Riß/Eem-Profil Nieselach (Kärnten): Altersstellung, Paläoklima und Sedimentationsbedingungen. in: Van Husen, D. (Ed.): Klimaentwicklung im Riss/Würm Interglacial (Eem) und Frühwürm in den Ostalpen. Mitt. Komm. Quartärforsch. 12: 141-154, Österr. Akademie der Wissenschaften, Wien.

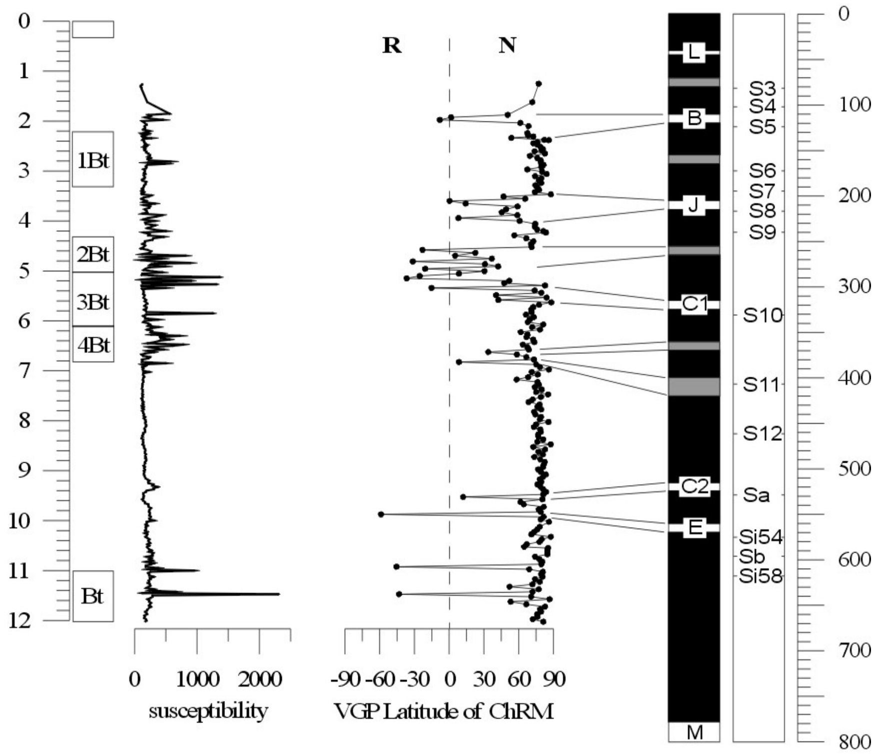

Fig.1: Preliminary age determination by means of combined magnetostratigraphy and climate-cyclicity analyses for a loess-paleosoil sequence near Wels in Upper Austria (Scholger & van Husen, in prep.). Left scale gives stratigraphic position (in meters), right scale for age (in 1000 years).